The Nature of Science Text

1. Pre-read any headings or pictures and number the paragraphs.
2. During reading mark up the text

-circle any unknown vocabulary words

-underline any proper names (person, place or thing that is named)

-highlight the main point of every paragraph

1. Annotate

-go back to the highlighted points and paraphrase them in your own words in the margin.

-look up the circled terms and write a definition to the term in the margin (or a synonym)

What does it mean to talk about the nature of science?

In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge. Many of these intrinsic ideas are lost in the everyday aspects of a science classroom, resulting in students learning skewed notions about how science is conducted.

What are the main ideas regarding the nature of science?

**1. *Scientific knowledge is tentative.*** Although scientific knowledge is supported by a wealth of data from repeated trials, it is not considered the final word. Scientific knowledge is at the same time stable and malleable. Scientists continually test and challenge previous assumptions and findings. After all, science is a human endeavor, and we know human perspective is limited and fallible. This idea of fundamental uncertainty is vital to scientific studies and is the basis of great scientific discoveries.

**2. *Nature of facts/hypotheses/theories*.** Some key words in science are often misinterpreted.

Facts. Students often think of the pieces of scientific knowledge they learn as "facts." As mentioned in the last section, we should not refer to scientific knowledge as fact, because that would tend to perpetuate the idea that scientific knowledge is inalterable. Scientific facts are observable phenomenon in a particular situation. "Dinosaurs were cold-blooded" is not a scientific fact, because this phenomenon cannot be observed. "The caterpillar is 2.6 cm in length" is an example of a fact, because the phenomenon was observed in a particular situation.

Hypotheses. If you ask a student to tell you what a hypothesis is, you will likely receive the following response: "A hypothesis is an educated guess." Although a hypothesis is partly a "guess" in the sense that it is an idea, this inevitable definition is not adequate. A hypothesis is a statement, based on previous observations, that can be tested scientifically. The idea that a scientific hypothesis must be testable often eludes students.

Theories. In the colloquial everyday language, theories are often ideas that have not been validated. In science, a theory has a much stronger meaning. Scientific theories are broadly based concepts that make sense of a large body of observations and experimentation. Because theories successfully tie together such a huge amount of information, they are among the most important ideas in science.

**3. *Scientific methods.*** In the first chapter of most science textbooks, there will be a section laying out "the scientific method," a step-by-step process that apparently must be followed in order to conduct scientific studies. The danger in this approach is not only that learning the scientific method is a bummer to students, but that it is also quite restrictive in its scope. Scientists usually do not walk through the method sequentially. They often bounce around, perhaps forming a new hypothesis during experimentation. Studies in which no experimentation is performed are also valid scientific studies, but do not follow the scientific method. For example: Jane Goodall observed the behavior of the apes in Africa and did not experiment on them, yet her research is still considered science. This butterfly study is a good example of an observational study which does not follow the scientific method, yet students record scientific data and create scientific conclusions.

**4. *Observations and inferences.*** It is important for students to understand the difference between observation and inference. However, this knowledge in itself is not enough. Students should also learn to make good observations and inferences, and understand the role that observations and inferences play in the development of scientific knowledge.

Observations. When we describe an environment based on our five senses, it is called an observation. For example, "Upon magnification, the painted lady eggs appear bluish and barrel-shaped." Observations are direct enough that most would make the same observation in the same situation.

Inferences. When we bring our past experience into making a judgment based on an observation, it is an inference. For example, "The caterpillar appears as if it is about to form its chrysalis" is an inference, because you are interpreting observations according to knowledge from past experience. Inferences are important in science in making explanations, but one must be careful not to confuse observations with inferences when conducting a study.

**5. *Human error.*** Although we take steps not to make errors in observation or experimentation, scientists are still human and make mistakes. It is important to challenge students to view their mistakes or unexpected results as potentially helpful. Scientific studies are most often riddled with problems that must be addressed. Often, scientists do not find the answer they expect, but if they do not allow their expectations to cloud their judgment, they may be able to approach the problem in a more appropriate manner.

**Follow up Questions (On another piece of paper in blue/black ink or typed. Put the question into your answer in full sentences):**

1. Who do you think the audience is for this piece of writing? What is the purpose or message the author is trying to get across? Support that with a quote from the article.
2. Why do you think that scientific hypotheses must be testable? How do hypotheses relate to theories?
3. How does the article suggest that errors can actually be helpful in the scientific process?